# Hydration and Urine Quality in Workers Exposed to Heat Stress (Study on Ceramic Production Workers)

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***Abstract*: Workers in the ceramic industry were exposed to high heat stress every day, that can caused dehydration. Dehydration can be identified by urine color, urine pH, and urine specific gravity (USG). It is also necessary to know urine quality to indicate the health condition of workers, including by turbidity, presence of protein, epithelium, bacteria, and leucosit. This research is analytic and descriptive, with a cross-sectional. The population and sample are all workers in the ceramic industry center in Klampok Village, Banjarnegara Regency, Central Java, are 55 workers. The variables studied were heat stress, amount of drinking water consumption, dehydration status, and urine quality. Heat stress is measured using a heat stress meter, the amount of drinking water consumption is identified through interviews, dehydration status is measured through urine examination taken after work and analyzed in the Banjarnegara District Health Office laboratory, including color (with standard urine color indicator), pH (with digital pH), and the USG (with a refractometer). The quality of urine is seen from the turbidity, the presence of protein, epithelium, bacteria, and leucocyte levels that analyzed in the laboratory. Based on the urine pH no worker is dehydrated. However, based on the urine colour, 60% of the workers were dehydrated, and based on the USG, 76.4% of the workers were dehydrateded. The relationship between the amount of water consumption based on urine color, p value = 0,013, and based on USG p value= 0,863. 21,8% urine were cloudy, 91% positive protein, 91% positive leucosite, 96,4% normal epithel, 100% positive contains bacteria. There is a relationship between the amount of drinking water consumption with dehidration status based on urine color.***

***Key words*: dehydration, heat stress, water consumption.**

## I. BACKGROUND OF THE STUDY

Climate change is driving an increase in heat-exposed workers.[1] People who are exposed to heat and humidity globally could increase from 275 million now to 1.22 billion annually when warming increases by about 3°C.[2] The hot climate is the dominant work environment factor in Indonesia, considering Indonesia's position in the tropics with high average air temperatures. Exposure to heat in workers can have direct consequences on health and performance of workers. Working under high heat stress, workers must reduce work intensity and rest longer to prevent an increase in internal body temperature, which if too high can cause dehydration, mental fatigue, impaired decision-making, physical exhaustion, heat stroke, and fainting.[3], [4], [5], [6], [7]. Dehydration is the loss of fluids or ions in the human body where more water comes out or undergoes excretion compared to the intake or consumption of fluids in the body.[8], [9].

Many factors can affect dehydration including the use of clothing, physical activity, length of work, type of work, amount of drinking water consumption by workers, and environmental factors such as hot climate and humidity.[10], [11], [12], [13] An important factor associated with the onset of dehydration in workers exposed to heat is the pattern of fluid consumption. The amount of drinking water consumed by workers in hot climates should be higher and less consumption can lead to dehydration.[14], [15] The amount of drinking water needed by the body is 2 liters or 8 glasses. Workers in hot environments are recommended to consume 2.8 liters of drinking water/per day so as not to cause dehydration.[16] However, according to NIOSH, workers in hot places are advised to consume 200 ml of water every 20 minutes, to replace fluids that come out during work and are exposed to high heat.

Assessment of dehydration can use several parameters including urine color, urine pH, and urine specific gravity.[17],[18], [19]The higher the dehydration, the more concentrated the color of the urine (darker color).[18] The darker the yellow color of the urine, the more acidic the urine, and the greater the specific gravity of the urine, indicating that the amount of fluid in the body is reduced compared to the amount of fluid flowing out of the body.[20] In addition to these three parameters, it is also necessary to know other descriptions of urine quality to indicate the health condition of workers, including by looking at turbidity, presence of protein, blood quality, presence of epithelium, and bacteria.

The type of work affects the onset of dehydration.[21] Workers in ceramic production are jobs that are exposed to high temperatures every day. The ceramic industry in Indonesia is mostly an informal industry, where the aspect of health care for workers receives less attention. The ceramic industry in Klampok Village Banjarnegara produces ceramics for household furniture with an average production of 65 pieces/day. The number of workers is 55 people, consisting of 45 men and 10 women. The average length of work is 8 hours/day, with 1 hour of rest time which does not coincide because there are workers who have to wait for the furnace. In the production process, workers are divided into 2 parts, namely the ceramic processing unit (covering printing, burning, drying, and coloring ceramics), and the ceramic processing product finishing unit. The industry uses a ceramic kiln that has a temperature of ± 300°C, with a volume of $25m^3$. The

production process has the risk of giving the effect of high heat exposure due to ceramic combustion.

Every day the industrial owner prepares 5 gallons of mineral water and is often provided with additional drinking water such as coffee, tea, and energy drinks at 01.00 PM. Drinking water is placed at a distance of ± 10 m from the production site. The purpose of this study was to describe the problem of dehydration and urine quality in ceramic production workers.

*Objectives*

The main purpose of this research was to analyze the relationship between the amount of dringking water consumption and dehydration status, and describe the quality of urine workers exposed to heat.

## II. RESEARCH METHODOLOGY

*2.1 Research Design*

This research is analytic and descriptive, with a cross-sectional approach.

*2.2 Location of the study*

Location of the study in the ceramic industry center in Klampok Village, Banjarnegara Regency, Central Java Indonesia.

*2.3 Target Population*

The population is all workers in the ceramic industry center in Klampok Village, Banjarnegara Regency, Central Java, totaling 2 locations with a total of 55 workers. The sample is the entire population.

*2.4* Data Collection Instruments

Heat stress is measured using a heat stress meter, the amount of drinking water consumption is identified through interviews, dehydration status is measured through urine examination taken after work and analyzed in the Banjarnegara District Health Office laboratory, including color (with standard urine color indicator), pH (with digital pH), and the specific gravity of urine (with a refractometer). The quality of urine is seen from the aspect of turbidity, the presence of protein, leucocyte levels, the presence of epithelium, and the presence of bacteria analyzed in the laboratory. Ethical clearance was obtained from the Health Research Ethics Commission, Faculty of Public Health, University of Muhammadiyah Semarang no 476/KEPK-FKM/Unimus/2021.

*2.5 Data analysis*

Data analysed using descriptive and inferential statistics (chi square test).

## III. FINDINGS AND DISCUSSIONS

Some workers are classified as elderly, and the length of work is still within the range that meets the standard, which is a maximum of 8 hours/day. The average amount of drinking water consumption is still below the standard required by workers in hot places, which is 3.6 liters, and the average urine specific gravity (USG) is 1.02 which indicates an abnormal condition.

Table 1.1 Demographic Characteristics

| Variable | Minimum | Maximum | Avergae | Standard Deviation |
|---|---|---|---|---|
| Age | 20 | 61 | 36,33 | 11,9 |
| Work periode | 5 | 8 | 7,02 | 1,421 |
| Amount of Water Consumption (ml) | 1500 | 4800 | 3594,55 | 1161, 324 |
| pH urine | 5 | 7,5 | 6,1 | |
| Urine Specivic Gravity (USG) | 1,005 | 1,03 | 1,02 | 1,012 |

*Dehidration on Worker*

The dehydration status of the workers was identified by the color, pH, and USG. If the status of dehydration is categorized as follows:

Table 2. Dehidration Status of Worker

| Dehidration Status | f | % |
|---|---|---|
| a. Based on urine pH: | | |
| - Dehidration | 0 | 0 |
| - No dehidration | 55 | 100 |
| b. Based on urine colour: | | |
| - Dehidration | 33 | 60 |
| - No dehidration | 22 | 40 |
| c. Based on USG: | | |
| - Moderate Dehidration | 11 | 20 |
| - Light Dehidration | 31 | 56,4 |
| - No dehidration | 13 | 23,6 |

Based on table 2 shows that based on the pH of the urine no worker is dehydrated. However, based on the color of the urine, 60% of the workers were dehydrated, and based on the specific gravity of the urine, 76.4% of the workers were dehydrateded. The following is a cross-distribution of dehydration status based on the amount of drinking water consumption:

Table 3. Dehydration Status Based on Amount of Drinking Water Consumption

| Dehydration Status (Urine Colour) | | | | | |
|---|---|---|---|---|---|
| Water consumption | Dehydrated | | Not dehydrated | | p-value |
| | f | % | f | % | |
| Enough (≥4800 ml) | 0 | 0 | 22 | 100 | 0,000 (OR=0,013) |
| Not enough (<4800 ml) | 33 | 100 | 0 | 0 | |
| Dehydration Status (USG) | | | | | |
| Water consumption | Dehydrated | | Not dehydrated | | |
| | f | % | f | % | p-value |
| Enough (≥4800 ml) | 14 | 77,8 | 4 | 22,2 | 0,863 |
| Not enough (<4800 ml) | 28 | 75,7 | 9 | 24,3 | |

Table 3 shows that based on the color of urine, all workers who consume enough drinking water are not dehydrated, while out of 33 workers who do not consume enough drinking water, all of them (100%) are dehydrated. The hypothesis test showed that there was a difference in dehydration status based on the amount of drinking water consumed. Workers who consume less water are at risk of becoming dehydrated 0.013 times compared to workers who consume enough drinking water. Based on the specific gravity of urine, both those who consume enough or less drinking water are entirely dominated by the dehydration category. The hypothesis test showed a p-value of 0.863 which means that there is no difference in dehydration status based on the amount of drinking water consumption based on the specific gravity of urine.

*Urine Quality*

Aspect of turbidiry, the presence of protein, leucocyte levels, and the presence of bacteria as follows:

Table 4. Urine Quality

| Urine Quality | f | % |
|---|---|---|
| Turbidity | | |
| - Clear | 43 | 78,2 |
| - Cloudy | 12 | 21.8 |
| The presence of protein | | |
| - Positive 1 | 9 | 16,4 |
| - Positive 2 | 2 | 3,6 |
| - Trace | 39 | 70,9 |
| - Negative | 5 | 9,1 |
| The presence of Leucosit | | |
| - Normal (0-5) | 5 | 9 |
| - Abnormal (>5) | 50 | 91 |
| The presence of Epithel: | | |
| - 0-4 | 53 | 96,4 |
| - > 4 | 2 | 3,6 |
| The presence of Bacteria: | | |
| - 1+ | 55 | 100 |

Based on the description of the quality of urine that needs attention is the presence of protein, the presence of leukocytes, and bacteria which these three parameters indicate that most of the workers are in a state that exceeds the normal value.

## IV. DISCUSSION

Health problems experienced by workers who work in hot environments include the problem of dehydration. Dehydration is the loss of fluids or ions in the human body where more water comes out or is excreted compared to the intake or consumption of fluids in the body.[9],[22] The amount of drinking water consumed by workers in hot climates should be higher than the general population, less consumption can lead to dehydration.[14] In general, the amount of drinking water the body needs is 2 liters/per day. For workers in hot environments, it is recommended to consume drinking water 2.8 liters/per day so as not to cause dehydration [16]), even according to NIOSH, workers in hot places are advised to consume 200 ml of water every 20 minutes, to replace fluids that come out when work and are exposed to high heat.

There is a difference in the amount of dehydration status between tests with pH, color, and specific gravity of urine. Based on urine pH, none of the workers were dehydrated. The average pH is 6.1. Under normal conditions, the urine pH ranges from 4.5 to 8.0, thus the urine pH of all workers is in the normal category. Urine is said to be acidic if it is at a pH below 5.0 and alkaline if it is at a pH above 8.0. Acidic urine, one of which indicates the presence of acidosis, dehydration, and diabetic ketoacidosis. Acidosis can occur due to increased levels of acid in the blood due to the kidneys not being able to excrete excess acid levels through urine. Based on this, workers are not at risk.

Based on the color of urine as much as 60% of workers are dehydrated. The amount of drinking water consumption is related to dehydration status based on urine color, with an OR value of 0.013 which means that workers who do not consume enough drinking water have a 0.013 times greater risk of becoming dehydrated. When workers are exposed to high heat, the body will react by opening the pores in the skin wider to release heat in the form of sweat. Sweating indicates the presence of fluid in the body that is expelled.[23] Thus the amount of drinking water consumed determines the dehydration status based on the color of the urine. Workers consume more water for their daily needs while working. 11 workers have the habit of drinking coffee, 8 workers drink tea, and 16 workers consume energy drinks at work and during work breaks. The effects of diuretic types of drinks such as coffee and tea can increase the rate of urination. Caffeine can stimulate the muscles in the bladder to become weak or overstimulated.[24] This is in line with research on tofu factory workers at UD Sumber Kencana that there is a relationship between drinking water consumption and dehydration status.[14]

Based on the specific gravity of the urine of workers who are dehydrated as much as 76.4%, which is classified as mild and moderate dehydration. The specific gravity of urine shows the concentration of particles in the urine and the density of the urine compared to the density of water.[25]The main substances in urine are urea, chloride, sodium, potassium, phosphate, uric acid, sulfate, and water.[26]Through the regulation of body water and electrolytes by the kidneys, the human body can maintain osmotic pressure homeostasis.[27].

Antidiuretic hormone (ADH), also known as Vasopressin, plays a role in maintaining water balance in the body. When the body is dehydrated, vasopressin is released from the brain into the bloodstream, where it then acts on the kidneys by holding water from being excreted in the urine. Vasopressin harms the kidneys if levels are consistently high. In heat-exposed workers, persistently elevated vasopressin induces an increase in intraglomerular pressure and glomerular hypertrophy. Urinary nephrin which is one of the constituents of the liaison between cells in the glomerulus becomes stretched so that it is excreted into the urine. Nephrine is a part of the glomerulus of the kidney that is usually absent or present in very small amounts in the urine. An increase in the level of nephrin in the urine indicates damage to the structure of the

glomerulus.[28], [29] A urine-specific gravity of 1.018 is associated with an increase in urinary nephrin. In this study, the average urine specific gravity reached 1.02, meaning there has been an increase in urinary nephrin or an abnormal condition. Thus, all workers in the ceramic industry have the potential to experience kidney problems if they are not handled properly. The drinking water consumption in the subjects of this study was mostly still below the recommended amount, even though the minimum value was still below the average needs of ordinary people (not workers in hot environments). However, in this study, drinking water consumption was not a factor that played a role in the formation of large urine-specific gravity. Physical work in high-heat climates results in the expenditure of more body fluids so that the volume of body fluids decreases.[30] A decrease in body fluid volume encourages the kidneys to retain water so that the concentration of particles in the urine will increase compared to the density of water. Thus, there will be an increase in the specific gravity of urine.[31],[32], [33] There is no relationship between the amount of water consumption and the dehydration status based on the specific gravity of urine. nephrin content in almost all the urine of workers. Nephrine formation is a long-term accumulation of hot work environment factors and a lack of drinking water consumption.

21.8% of the workers' urine was cloudy. Urine turbidity is generally caused by bacteria, erythrocytes, leukocytes, lymph fluid, lipids, mucus, yeast, crystals, or amorphous salt deposits. [34] 50 (91%) workers indicated the presence of protein. Excess protein in the urine can indicate certain diseases, especially kidney disorders. In healthy kidneys, normally no or only a small amount of protein is found in the urine. When the kidneys are impaired, the ability of kidneys to filter and absorb proteins in the blood will be disrupted. As many as 70.9% of the workers showed the presence of trace protein, this indicates an abnormality in the urine where the protein was found to be occult. The presence of trace protein one of which indicates a kidney disorder.

The presence of bacteria and leucocytes was found in all workers, even 91% of workers had leukocyte levels > 5 cells per high power field (HPF). For significant consideration of urinary tract infection, the presence of bacteria in the urine must be accompanied by a leukocyte count. [35] The presence of bacteria can indicate a urinary tract infection, inflammation in the urinary tract, kidney disorder, or infection. This is supported by the presence of leukocytes in the research subjects, which function to fight microorganisms such as bacteria that are infecting the body. Leukocyte esterase is produced by neutrophils and has been associated with urinary tract infections.[36] In the case of urinary tract infection, there is an increase in the number of bacteria, increasing the population of white blood cells because the immune system is activated. In some cases, squamous cells are present. Squamous cells, in numbers outside the norm, deserve special attention because they can be the beginning of a more severe pathological condition.[37] However, when viewed from the data, urine epithelial cells in this study were still within safe limits. 2 workers have epithelial levels above normal limits.

Based on the specific gravity of the workers' urine, in general, there has been an increase in urinary nephrin, which indicates a change in the structure of the kidney's glomerulus. The presence of bacteria and leukocytes is also suspected due to an infection in the urinary tract, inflammation in the urinary tract, kidney disorders, or infections. Urinary tract infection is a condition that can affect any part of the urinary system, even to the point where it can spread to the kidneys. This kidney infection can occur when bacteria move into the urinary tract and then infect the kidneys

## V. CONCLUSION

The lack of water consumed is at risk of causing dehydration based on the color of urine. In general, the quality of the workers' urine shows abnormal conditions, especially in the aspect of the presence of protein, leukocytes, and bacteria.

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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